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AIC-21

Information Sheet on
Building, Equipment, and Labor Requirements and Processing Costs in Dehydration

CARROTS, POTATOES, RUTABAGAS, AND SWEETPOTATOES

Western Regional Research Laboratory, Albany, California
Bureau of Agricultural and Industrial Chemistry
Agricultural Research Administration
U. S. Department of Agriculture

The construction and operation of a dehydration plant in wartime are somewhat different from a similar enterprise in time of peace. The main differences result from the scarcity of critical materials and labor. Monetary costs are a secondary consideration, whereas in time of peace they are paramount. The task in wartime is to produce the desired quantity of quality goods when needed. From the standpoint of plant construction and process, the problem is largely one of engineering and technology. However, proper construction and operation of these plants are matters to study from a cost standpoint, since efficiency is best measured in terms of dollars and cents.

This discussion deals with plant layout and equipment and labor requirements, mainly from a cost standpoint. There is no intention to engineer a plant nor to advocate certain methods of processing. Engineering and technological considerations are discussed only in relation to the probable cash outlay for plant and the probable processing costs under the conditions as stated.

Even though the cost of the plant and equipment may appear high, it is only a minor consideration in determining the processing cost per dry pound. The day-to-day charges such as labor, raw material, packaging supplies, etc., are by far the greater. In many cases the cost of raw material, labor, and packaging supplies for only one month amount to more than the total initial investment for plant and equipment. Capital investment should, nevertheless, be given careful consideration. The type of building, kind of equipment, and plant layout are important factors in efficient operation of any dehydration plant. A plant must be so engineered as to make the most efficient use of labor, equipment, and floor space, and to handle raw materials without damage and waste, if low operating costs are to be attained.

The various units of a dehydration plant must work together as an integrated whole. A properly planned dehydration plant is not built around a particular piece of equipment nor around a certain step in the process. The different operations must be balanced, with no "bottlenecks." To accomplish this, the capacity of each piece of equipment should be somewhat flexible so that an operating balance can be secured without seriously impairing the efficiency of any part of the plant. New plants should be completely engineered before construction begins. Otherwise, costly changes may be required later.

The series of processing steps usually followed in the dehydration of carrots, potatoes, rutabagas, and sweetpotatoes is shown in the accompanying flow sheet, (fig. 1). These steps are standard procedure in many dehydration plants. The steps as shown have proved to be satisfactory in operation. These

four vegetables are considered together because they can be handled on the same preparation line if lye or brine peeling is used. Because of the drying characteristics of sweetpotatoes, the dehydrator for them must have more tray area than for the other vegetables, in order to achieve the same capacity. The plant layouts as presented can handle sweetpotatoes satisfactorily but with less capacity than indicated on the drawings. Except for the drier, the remainder of the plant is substantially the same.

The discussion that follows is based upon the steps shown in the flow sheet and assumes the preparation of carrots in cubes, potatoes in strips, and rutabagas and sweetpotatoes in slices. Other methods of cutting can be used but they will affect either the capacity as stated or the amount that can be put into a given size of container. Both may affect processing costs.

Other vegetables can probably be handled on this same lineup. Among these are tomatoes and parsnips. Table beets are sometimes given a precook sufficient only to loosen skins and set the color and are then blanched after cutting. A suitable prescalder may be the only additional equipment needed.

Building Requirements

The building need not be expensive, but certain features are essential. It must have good concrete floors throughout and proper drainage so that walls and floors can be washed down and kept clean. All outside openings should be screened so that flies and other insects cannot enter, and outside screen doors should have automatic closing devices. Rodent-proof construction is highly desirable.

The plant layouts presented here show practical floor plans and will serve as guides to floor-space requirements and arrangements for the different operations. Buildings of rectangular shape are used for illustrations because they are a commonly used type. If the plant is to be located in existing buildings, the layout must be modified to take advantage of the available space in the best manner.

In some cases it may not be feasible to locate all parts of the plant within the limits of a rectangular building. Mezzanine floors and smaller, adjoining buildings can be used.

A summary of the requirements of various sections of the building is given in table 1. Preferred location and other considerations are included. On the basis of actual floor space in operating plants and an objective appraisal of the adequacy of these allowances, approximate floor space requirements for various parts of the plant are given in table 2.

Figures 2 to 6 present plant layouts for dehydration plants ranging in size from a capacity of 5 to 100 tons per day, unprepared basis.

TABLE 1.--General requirements for various sections of the building

	Preferred location	Ventilation and temperature	Other considerations
Raw material storage	Adjacent to preparation room and receiving platform.	Cool and dry.	Easily cleaned. Screened from insects. 2 to 3 days' supply of material on hand may usually be considered a minimum in determining space requirement.
Finished product storage	Adjacent to packaging room and shipping platform.	Cool and dry.	Insect and rodent proof. Space dependent upon regularity of outgoing shipments and stock of packaging supplies required.
Preparation	Commodious part of building.	Adequate ventilation, no objectionable odors.	Built in waste flumes in floor are desirable.
Drying	Located so that no other activities will interfere with movement of cars. Allow for possible future expansion.	Provide outside outlets for exhaust air.	Provide adequate storage space for trays and trucks and avoid cross traffic in movement of trays and trucks.
Packaging	Out of line of traffic. Near finishing bins and adjacent to finished product storage.	Provide dry air.	Partition from rest of building.
Boiler	Near place of greatest steam use, but away from other activities.		
Laboratory	Depends upon plant layout and operator's preferences.	Analytical balances and other equipment affected by changes in temperature and humidity. Room should be free from excessive dust.	If located near heavy pounding, such as may occur in machine shop, the analytical balances may be disturbed.
Locker and wash rooms	Near preparation room to avoid excessive traffic.	Provide outside ventilation.	
Office	Overlooking shipping and receiving platform and possibly preparation room.		
Machine shop	Near tray storage and preparation room.		Provide space for repair parts and idle equipment.
Sewerage	Near preparation room but away from other activities.	Keep air and odors from main parts of building.	Provide easy removal of waste material.

TABLE 2.--Approximate floor space requirements 1/ for carrots, potatoes and rutabagas 2/ in square feet

	5-ton plant 3/		25-ton plant 3/		50-ton plant 3/		100-ton plant 3/		Allowed in sketch				
	Low	High	Low	High	Low	High	Low	High	5-ton plant	25-ton tunnel	25-ton conveyor	50-ton plant	100-ton plant
Raw material storage 4/	400	800	2,000	4,000	4,000	8,000	8,000	16,000	500	2,600	2,500	4,600	8,600
Finished product and packaging supplies storage 5/	400	800	2,000	3,500	3,000	6,000	6,000	12,000	500	2,900	2,500	4,600	8,500
Preparation	400	600	1,500	2,500	2,500	3,500	4,000	6,500	450	1,800	2,100	3,200	6,000
Drying 2/ 6/	1,000	2,000	3,500	5,000	7,000	9,000	10,000	14,000	1,400	4,000	2,600	7,800	13,000
Packaging	100	200	400	600	500	800	800	1,000	150	500	500	700	1,000
Boiler room 7/	100	200	300	500	500	800	800	1,200	100	300	500	500	800
Laboratory	--	--	100	200	200	400	300	500	--	150	150	300	400
Locker and wash rooms	200	400	500	1,000	1,000	1,500	1,500	2,500	250	700	700	1,100	1,800
Office	--	--	300	500	400	600	500	750	--	450	400	500	600
Machine shop and tray repair	--	--	200	400	400	800	500	1,000	--	300	200	500	700
Sewerage 8/	--	--	200	300	400	600	500	1,000	--	300	250	400	600
Total	2,600	5,000	11,000	18,500	19,900	32,000	32,900	56,450	3,350	14,000	12,400	24,200	42,000

1/ The low limits of floor space will be undesirable in most instances.

2/ Because of their drying characteristics and because they require more tray area than allowed herein, sweetpotatoes are not included here. Other space requirements are substantially the same.

3/ Capacity given in tons per 24 hours, unprepared basis.

4/ The space indicated for raw material storage will provide from 2 to 3 days' supply of root vegetables in sacks or boxes. Additional space must be provided if a larger supply of raw material is to be kept on hand. If it is not feasible to have this storage space in one building, adjoining buildings or covered platforms can be used.

5/ Additional storage space, 50 percent or more of that indicated here, should be provided on mezzanine floors or in separate buildings for storage of chemicals, spare equipment, and other items that accumulate. It is assumed here that these dehydration plants are on a war basis and finished goods are shipped as soon as shipping facilities are available. However, for normal operation in peace time, plants of the same capacity will ordinarily need more space for storage of finished goods.

6/ Floor space allowances for the dehydrator are based upon truck and tray tunnel driers.

7/ Floor space allowances for the boiler room are based upon the use of steam for blanching and incidental uses only. If steam-heated driers are used, more space will be needed.

8/ In many instances no space need be allocated for sewerage. Space indicated here is for settling and separation of solids from liquid wastes and for trimmings from the preparation line.

Equipment Requirements

Preparation equipment. - Figure 8 presents the layout of the preparation line for the 100-ton plant. Both the side elevation and floor plan are shown. The line need not be straight; it can be turned at any one of a number of convenient places as illustrated in the plant layouts.

Only properly designed and carefully built machinery should be used. A poor cutter or slicer may cause damage to the product and increase washing losses. Incomplete peeling necessitates excessive trimming labor, and drastic peeling wastes the product. The initial cost of a good blancher and its operating costs are small compared to the loss that will be incurred by the use of one poorly designed. Improperly designed elevators, conveyors, and washers may be too rough in their action, resulting in damage to the product.

Ruggedness and long operating life are important. High initial costs are justified when they result in reduced repairs and replacements. Repairs cause grief and expense due to interruption of production and improper handling and processing.

Where there is a possibility that the stopping of any machine will interrupt the continuous flow of the product through the plant, some means of substitute operation should be available or else there should be water immersion storage facilities for the unfinished product so that it will not deteriorate. In larger plants it may be justifiable to provide two of almost all major items of equipment, not only because of the possibility of a breakdown but also from an operating standpoint. For example, two or three trimming belts are preferable to one, and it may be desirable to provide two smaller blanchers instead of a single large one. This arrangement has particular value when two products are run simultaneously or the product is being prepared in two forms.

Oversized equipment may be a wise investment. Various parts of the preparation line are then able to handle increases in throughput which may occur as a result of improvement in quality of raw material or changes in labor and equipment.

On the other hand, much can be done to reduce investment in processing equipment. The number of elevators and conveyors can be reduced by placing some machines on elevated platforms directly over other machines, thus utilizing gravity flow. This also reduces the floor space required. Elimination of all unnecessary handling of the material reduces the amount of labor and equipment needed and results in a better finished product.

Table 3 presents a summary of operating steps in the preparation of raw material for drying with a brief description of salient points to be considered in choosing the equipment.

Choice of drier.- Three types of vegetable dehydrators are shown in figures 2 to 6. Figure 2 shows a plant capable of handling 100 tons of raw product per day, in continuous operation. The dehydrator is of the multistage

TABLE 3.--General requirements for preparation steps and equipment

Step	Method	Special features	Remarks
Feeding to preparation line	By conveyor, or manually using hand trucks.	Provide large hopper or soaker washer to insure continuous feed along the preparation line.	Preliminary sorting may be done on the conveyor. Front end of line usually very dirty -- advisable to install dry-cleaner ahead of line -- assists in keeping dirt out of the sewer.
Washing	Usually a rotary washer.	Provide sand trap to keep dirt out of sewer. High-pressure sprays are sometimes desirable.	Elevator to washer may be equipped with water sprays.
Peeling	Best probably lye or brine peeling scalder. Abrasion and flame peelers are also used.	Peel removed after scald by high-pressure washer or by shaker-washer.	Pre-blancher may be necessary to assist in the maintaining proper temperature in scalder. Advisable if abrasion peeling is used.
Trimming	By hand, women standing alongside conveyor belt.	Merry-go-round feature has many advantages. Provide good lighting.	Provide about 3 feet of space along belt for each woman. 30 inches is a desirable minimum.
Cutting	By a continuous cutter which will slice, strip, or dice the vegetable as desired.	Provide screen and magnets to remove foreign objects from material before reaching the cutter.	Elevator to the cutter may be equipped with water sprays.
Blanching	On trays in a cabinet or on a tray conveyor, or on a continuous belt.	Front and rear uncovered section of blancher belt may be equipped with water sprays.	
Waste disposal	Settling tanks, sewage separators, grinders, etc.	Conveyor from trimming table to carry trimmings.	

tunnel type. Figures 3 and 4 show 50- and 25-ton plants with driers of the counterflow tunnel type, and figure 5 a 25-ton plant with a conveyor-type drier. All are planned to include finishing bins.

This presentation is not meant to imply that a multistage unit is better for a 100-ton plant, and a conveyor type for a 25-ton plant. The examples are presented for illustrative purposes only and it is probable that each of these types will be used in the future in a wide range of plant capacities. The capacities indicated are only nominal; the true capacity of each is dependent upon the product, the drier design, heat input and air circulation, and the use of finishing bins.

In the multistage drier, the material passes first through a parallel-flow tunnel, then through a counterflow tunnel, and finally into finishing bins. If properly designed, this is a very flexible type of unit, permitting the adjustment of drying conditions to the optimum for product quality. The second-stage tunnels, used alone, are suitable for fruit drying.

The counterflow tunnels illustrated in the 50- and 25-ton plants are a conventional type. Drying times are not as short as in multistage units because the maximum temperature of the air is limited by the highest temperature that the product at the dry end can stand. The use of finishing bins, permitting removal of the product from the tunnels at a higher moisture content, partially offsets this drawback.

The conveyor type of drier illustrated by the 25-ton plant has shown promise in commercial operation and will doubtless be used increasingly as its operating problems are overcome.

Figure 6 shows the layout for a plant handling 400 pounds of raw product per hour. If the operation is continuous, the plant will process about 5 tons of vegetables per 24 hours. The dehydrator is a 9-truck tunnel of small cross section, and it is assumed that one truck will be loaded every 50 or 60 minutes. The preparation line will probably be operated only one or two shifts per day; the drying will therefore continue only until all the product in the tunnel has been dried.

These smaller plants are not usually in a commercially competitive position unless they have some special advantages, such as low-cost raw material or low-cost labor. Small plants, operating as community projects or on individual farms, often justify themselves by making possible the saving of crops that have no ready market. Their value in wartime is limited by the fact that the output per unit of operating labor and construction materials is low.

The operation of plants much smaller than those handling 25 tons per day is likely to be intermittent, and batch-type driers or tunnels smaller than the usual commercial type may, therefore, be preferable. The use of tunnel-type driers in a discontinuous operation is feasible only if close control of temperature and humidity is maintained during the starting-up and shutting-down periods.

The choice of drier may be influenced by the amount of labor required. Although the output per dollar of investment for a conveyor dehydrator is generally less than for a tunnel drier, the lower labor cost in operating the former may offset the higher initial capital cost. If tray-type driers are used, all practical labor-saving methods and devices should be installed. Tray handling and washing may entail a considerable amount of hand labor, whereas belt cleaning may be almost entirely automatic. When labor rates are high, the rehandling costs involved in multistage drying may be sufficient to cause a reconsideration of the system to be installed. Automatic movement of the cars in and between the tunnels may overcome this disadvantage.

It may not be possible, however, to determine which type of dehydrator is preferable on the basis of cost alone. It is probable that the choice may be determined mainly by technological factors, and it may depend also upon the quality and quantity of output and relative availability of labor and materials.

Tunnel driers require considerable floor space because of the need for transfer tracks, car tracks, car and tray storage, tray washing equipment, and the tray conveyors used in loading. The conveyor-type drier requires relatively little floor space in addition to that occupied by the drier itself. Through circulation of air permits heavy loading on the belt, thus reducing its required size and minimizing needed floor space.

The upkeep of the drier is important. The cost of maintaining the trays in proper condition can be balanced against the upkeep of a large and costly belt or conveyor. Careful handling and proper maintenance lengthen the life of either type of equipment.

Ample capacity in the dehydrator is usually a good investment. Since the fuel and power costs are relatively low, an increase or decrease of even a substantial percentage does not seriously affect the total processing cost. Increased labor costs due to inefficient use of labor in the preparation line, when the dehydrator is unable to handle the output of the line, usually amounts to far more than any additional drying cost resulting from the use of a slightly oversized dehydrator.

Finishing bins used in conjunction with the dehydrator make it possible to utilize the full capacity of the dehydrator proper by shortening the time of the main drying operation. This shortening of drying time may result in an improvement in quality. The overall cost per unit of drying capacity will usually be less when finishing bins are used.

It will be noted that only air-blast driers are considered. The principal reasons for this restriction are that air drying is a proved method and that it generally gives the greatest output of product for a given quantity of critical construction materials. Various combinations of vacuum, radiant heat, and other drying aids may find increasing use as material shortages become less acute if dried products of superior quality can be produced by these other methods.

Loading and stacking trays.- One tray line is adequate for plants handling up to 100 tons per day. Proper timing of tray loading, stacking, drying, and tray scraping is essential for efficient operation. This is especially true for large plants. At least 10 to 12 seconds should be allowed for handling each tray at the loading point although the actual time involved in taking the tray from the loading table and placing it on the truck is somewhat less than this. On this basis a 100-ton plant is near the limit for one tray line. It should be borne in mind that if the rate is increased so that the handling time is less than 10 to 12 seconds per tray or if the flow of product is not uniform, two tray lines will be necessary.

Spreading the product on trays is slightly more difficult than spreading on a flat belt because the sides of the trays are higher than the material. Leafy vegetables, such as unblanched shredded cabbage, are an exception since this material is stacked higher than the sides of the trays. Several suggested means of spreading on trays are sketched in figure 7.

It is important that tray handling be avoided wherever possible. One possibility is illustrated in figure 9. After the trays are scraped and dumped, they are placed immediately on a tray conveyor which takes them back to be loaded again. Tray cleaning can be accomplished on this conveyor by means of high-pressure, hot-water sprays, revolving brushes, etc. A car standing alongside the conveyor can be used to furnish extra trays for loading when necessary. Two conveyors in series, the first running at a faster speed, help to maintain a continuous line of trays for loading. If this system is used, tray scraping and tray loading must be coordinated for efficient operation.

Packaging equipment.--The packaging room should be enclosed, thus excluding damp air from the preparation room and dehydrator. Air desiccating equipment is advisable in many cases. If a refrigeration system already is available, desiccation based upon refrigeration can be used. Where no such equipment exists, nonrefrigerative types are generally installed. When a product is dried to an extremely low moisture content, desiccation of air is essential and will more than pay for itself in improving the quality of the packaged material.

Where a shaker-sieve is used to remove the fines from the dried product, the economical use of these fines is a problem. If the quantity is large, installation of grinding equipment may be advisable. The necessity for grinding equipment also depends largely upon the demand for soup stocks, purees, and seasonings. Onions, celery, and garlic have been quite generally prepared in powder form, and powdering equipment will probably continue to find its greatest use for these vegetables. An extremely dry product and dry air are essential in any powdering operation.

If the product is packaged in 5-gallon cans, packaging equipment costs are very moderate. The can sealer is rented on a yearly basis at an extremely low rental fee, and only boxing or crating tools are required in addition. Other types of packaging usually require special equipment which in most cases is more expensive to install and operate. If the product is compressed before packaging, special techniques such as those described in AIC-5 will be involved.

Handling capacities and utility requirements.--The capacities per unit of time at various points along the processing line for the various sizes of plants are calculated in table 4. Such tables are of assistance in estimating labor requirements and equipment sizes for each operation. Although the operations are considered continuous, employees actually work less than 8 hours per shift because of time out for lunch and relief periods. An operating time of 7 hours per shift or 21 hours per day has been assumed.

Facilities must be available to provide approximately the quantities of heat, power, and water indicated in table 5. Direct-fired heat is assumed for the tunnel dehydrators, and steam heat for the conveyor drier.

The figures in this table allow for the difference in consumption of utilities under various operating conditions. The indicated demand load for electric power is really total connected load. The average operating load will be smaller.

Labor Requirements

Labor costs are so important in dehydration that efficient use of labor is essential if reasonable operating costs are to be attained. The number of employees in a dehydration plant is by no means fixed, and preliminary estimates of labor requirements are usually rough approximations because of the large number of factors affecting labor usage. Among these factors are: type of process, degree of mechanization, efficacy of equipment, effectiveness of plant layout, proper balance between operating steps, condition, variety, and grade of raw material, specification for finished product, labor laws and customs, working conditions, ability and training of employees, method of pay, morale, and operators' individual preference and policies. Not all of these factors can be evaluated in advance. The discussion presented here has been largely based upon observations made in canneries and dehydration plants and the opinions of experienced plant operators.

Table 6 shows the approximate labor distribution in dehydration plants of various sizes. The trimming, sorting, and inspection labor in commercial-size plants varies in almost direct proportion to the size of the plant. Thus, a 100-ton plant drying potatoes can be expected to require from 50 to 100 women on the trimming belt, a 10-ton plant, 6 to 10. This direct relation does not hold true for the other operations. As size of plant increases, the labor requirement per unit of output for these other operations decreases. Because of the need for at least one or more employees for each of many operations regardless of the through-put at those points, the smaller plants are at a disadvantage as compared to the larger ones which can make more efficient use of labor. Except for sorting and trimming, the labor requirements are substantially the same for these seven vegetables.

The method of peeling materially affects the number of trimmers needed. Abrasion peeling of potatoes may require as many as 50 women per shift in a plant handling 50 tons per day. Lye peeling may reduce that number to between 30 and 40. Flame or radiant-heat peeling, brine peeling, or other peeling methods may also result in a lower labor requirement for trimming.

TABLE 4.--Operating capacities per unit of time (operating actually 21 hours per day)

	Carrots (cubes)				Potatoes (strips)			
	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]
Unprepared basis:								
Lbs. per hour	475	2,400	4,750	9,500	475	2,400	4,750	9,500
" " minute	8	40	80	160	8	40	80	160
Prepared basis:								
Culling, peeling, and trimming loss	---------- 20% ----------				---------- 25% ----------			
Lbs. per hour	380	1,900	3,810	7,620	360	1,790	3,570	7,150
" " minute	6.4	32	64	130	6	30	60	120
Number of women trimming	3	10	20	40	5	20	40	80
Lbs. per woman per minute	2.1	3.2	3.2	3.2	1.2	1.5	1.5	1.5
Lbs. in blancher at a time (6-min.blanch)[2]	38	190	380	760	36	180	360	720
Active blancher surface, 4 lbs./sq.ft.[3]	10	50	95	190	9	45	90	180
Assumed tray loading - lbs. per sq.ft.	---------- 1.5 ----------				---------- 1.25 ----------			
Lbs. per 3x6' tray (3x4' for 5-ton plant)	18	27	27	27	15	22.5	22.5	22.5
Lbs. per car of 22 trays	395	595	595	595	330	495	495	495
Cars per hour[3]	1	3.2	6.4	12.8	1.1	3.6	7.2	14.4
Minutes per car	63	19	9.4	4.7	55	17	8	4
Trays per hour[3]	21	70	140	280	24	80	160	320
Trays per minute	0.4	1.2	2.4	4.7	0.4	1.3	2.7	5.3
Seconds per tray	170	50	25	13	150	45	22	11
Active length of blancher[3] 6' wide, if product is blanched on trays - in feet	-	21	45	85	-	25	50	100
Dried basis: Overall shrinkage ratio[4]	---------- 11 to 1 ----------				---------- 7 to 1 ----------			
Lbs. per day	910	4,560	9,100	18,200	1,430	7,140	14,300	28,600
" " hour	43	220	430	865	68	340	680	1,360
" " minute	0.7	3.7	7.2	14	1.1	5.7	11	23
Lbs. per 5-gal. package	---------- 17 ----------				---------- 10 ----------			
Packages per day	54	270	535	1,070	140	715	1,430	2,860
" " hour	2.5	13	25	51	6.8	34	68	136
Minutes between packages	24	4.7	2.4	1.2	8.8	1.8	0.9	0.4

TABLE 4.--Continued

	Rutabagas (slices)				Sweetpotatoes (slices)			
	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]
Unprepared basis:								
Lbs. per hour	475	2,400	4,750	9,500	475	2,400	4,750	9,500
" " minute	8	40	80	160	8	40	80	160
Prepared basis: Peeling and trimming loss	----------		15%	----------	----------		25%	----------
Lbs. per hour	405	2,025	4,050	8,100	360	1,790	3,570	7,150
" " minute	6.8	34	68	135	6	30	60	120
Number of women trimming	3	10	20	40	4	15	30	60
Lbs. per woman per minute	2.3	3.4	3.4	3.4	1.5	2.0	2.0	2.0
Lbs. in blancher at a time(6-min.blanch)[2]	41	200	405	810	36	180	360	720
Active blancher surface, 4 lbs./sq.ft.[3]	10	50	100	200	9	45	90	180
Assumed tray loading - lbs. per sq. ft.	----------		1.4	----------	----------		1.25	----------
Lbs. per 3x6' tray (3x4' for 5-ton plant)	17	25	25	25	15	22.5	22.5	22.5
Lbs. per car of 22 trays	375	550	550	550	330	495	495	495
Cars per hour[3]	1.1	3.7	7.4	14.7	1.1	3.6	7.2	14.4
Minutes per car	55	16	8	4	55	17	8	4
Trays per minute[3]	0.4	1.4	2.7	5.4	0.4	1.3	2.7	5.3
Seconds per tray	150	43	22	11	150	45	22	11
Active length of blancher[3], 6' wide if product is blanched on trays - in feet	-	25	50	100	-	25	50	100
Dried basis: Overall shrinkage ratio[4]	----------		10.5 to 1	------	----------		5 to 1	----------
Lbs. per day	950	4,760	9,520	19,050	2,000	10,000	20,000	40,000
" " hour	45	225	450	910	95	475	950	1,900
" " minute	0.8	3.8	7.5	15	1.6	7.9	16	32
Lbs. per 5-gal. package	----------		12	----------	----------		12	----------
Packages per day	80	395	790	1,590	170	830	1,670	3,330
" " hour	3.8	19	38	76	8	40	80	160
Minutes between packages	16	3.2	1.6	0.8	7.5	1.5	0.8	0.4

1/ Capacity given in tons per 24 hours, unprepared basis.

2/ Recent experiments indicate that under best blanching conditions the blancher can be loaded more heavily than indicated here. Some uncertainty also exists in regard to the blanching time required to secure satisfactory results. At higher blancher loading, the retention time must be longer.

3/ The blancher size and number of trays and cars handled are based upon total weight of trimmed material. The actual weight handled will decrease during washing, cutting, and blanching, because of leaching and loss of fines. On the basis of loadings indicated here, size of blancher and number of trays will be somewhat less than shown above.

4/ The overall shrinkage ratio is the ratio of weight of unprepared raw material to the resultant weight of dried product.

TABLE 5. Approximate utility requirements

Utility and application	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]
Water	Gallons per hour		
Potatoes and sweetpotatoes	2,500 to 5,000	5,000 to 10,000	10,000 to 20,000
Carrots, beets, rutabagas, and onions	2,000 to 4,000	4,000 to 8,000	8,000 to 16,000
Cabbage	600 to 1,000	1,200 to 2,000	2,500 to 4,000
Electricity	Kilowatts		
Demand load	50 to 70	80 to 125	150 to 250
Fuel	B. T. U. per hour[2]		
Dehydrator			
Direct heat	3½ to 5 million	7½ to 10 million	15 to 20 million
Indirect heat	8 to 13 million	15 to 25 million	30 to 50 million
Steam heat	5 to 8 million	10 to 15 million	20 to 30 million
Blancher [3] and incidental	1 to 2 million	2 to 4 million	4 to 8 million
Boiler capacity	B. H. P. (actual)[2]		
Blanching and incidental	25 to 50	50 to 100	100 to 200
Dehydrator	125 to 175	250 to 350	500 to 700

1/ Capacity given in tons per day, unprepared basis.

2/ The lower limits of heat requirement and boiler capacity for the dehydrator are considerably larger than needed for some vegetables under good operating conditions. On riced white potatoes, for example, the minimum heat requirement may be less than two-thirds of that indicated in the table.

3/ Low limit is based on continuous type blancher. If batch type blancher is used blanching steam demand will be higher.

TABLE 6.--Estimated labor requirements

	Number of employees per shift							
	Carrots				Potatoes			
	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]	5-ton plant[1]	25-ton plant[1]	50-ton plant[1]	100-ton plant[1]
Direct Labor								
Feeding to preparation line	1 M	1 M	1- 2 M	2- 3 M	1 M	1 M	1- 2 M	2- 3 M
Operating sizer and/or peeler			0- 1 M	0- 1 M			0- 1 M	0- 1 M
Sorting and trimming	3 F	10-13 F	20-25 F	40-50 F	4-5 F	15-25 F	30-50 F	60-100 F
Operating washer, slicer, etc.	1 M				1 M			
Spreading on blancher belt		0- 1 F	0- 2 F	0- 4 F		0- 1 F	0- 2 F	0- 4 F
Placing trays on conveyor		1 M	1 M	1- 2 M		1 M	1 M	1- 2 M
Spreading on trays		1- 2 F	1- 2 F	2- 4 F		1- 2 F	1- 2 F	2- 4 F
Loading cars	1 M	2 M	2 M	2- 4 M	1 M	2 M	2 M	2- 4 M
Moving cars and operating drier		1 M	2 M	3- 4 M		1 M	2 M	3- 4 M
Scraping trays	)	2 M	2- 4 M	4- 6 M)		2 M	2- 4 M	4- 6 M
Final inspecting	) 1 F	1- 3 F	2- 6 F	4-12 F)	1 F	2- 5 F	4- 8 F	8- 16 F
Packaging, crating and warehousing[1]	) 1 M	(2 F	3- 4 F	4- 6 F)	1 M	(2 F	3- 4 F	4- 6 F
		(2 M	2- 3 M	3- 5 M		(2 M	2- 3 M	3- 5 M
Other:								
Foreman	1	1	1	1	1	1	1	1
Forewoman	-	-	1	1	-	-	1	1
Helpers, cleanup, maintenance, etc.	1 M	2- 4 M	4- 6 M	8-12 M	1 M	2- 4 M	4- 6 M	8- 12 M
Total per shift:								
Men	5	11-13	14-21	23-37	5	11-13	14-21	23- 37
Women	4	14-21	26-39	50-76	5-6	20-35	38-66	74-130
Foremen	1	1	1	1	1	1	1	1
Forewomen	-	-	1	1	-	-	1	1
Indirect Labor								
Bookkeeper	)		1- 2	2- 3	)		1- 2	2- 3
Stenographers	) 1	2- 3	1	1- 2	) 1	2- 3	1	1- 2
Payroll and other clerks	)		1- 2	2- 4	)		1- 2	2- 4
Superintendent	)	1	1	1	)	1	1	1
Field men	) 1		1	1	) 1		1	1
Plant chemist (and assistants)	)	1	1	1- 2	)	1	1	1- 2
Total, one shift per day	2	4- 5	6- 8	8-13	2	4- 5	6- 8	8- 13

TABLE 6.--Continued

	Number of employees per shift							
	Rutabagas				Sweetpotatoes			
	5-ton plant 1/	25-ton plant 1/	50-ton plant 1/	100-ton plant 1/	5-ton plant 1/	25-ton plant 1/	50-ton plant 1/	100-ton plant 1/
Direct Labor								
Feeding to preparation line	1 M	1 M	1- 2 M	2- 3 M	1 M	1 M	1- 2 M	2- 3 M
Operating sizer and/or peeler			0- 1 M	0- 1 M			0- 1 M	0- 1 M
Sorting and trimming	3 F	10-13 F	20-25 F	40-50 F	3-4 F	13-18 F	25-35 F	50-70 F
Operating washer, slicer, etc.	I M				1 M			
Spreading on blancher belt		0- 1 F	0- 2 F	0- 4 F		0- 1 F	0- 2 F	0- 4 F
Placing trays on conveyor		1 M	1 M	1- 2 M		1 M	1 M	1- 2 M
Spreading on trays		1- 2 F	1- 2 F	2- 4 F		1- 2 F	1- 2 F	2- 4 F
Loading cars	1 M	2 M	2 M	2- 4 M	1 M	2 M	2 M	2- 4 M
Moving cars and operating drier		1 M	2 M	3- 4 M		1 M	2 M	3- 4 M
Scraping trays	)	2 M	2- 4 M	4- 6 M	)	2 M	2- 4 M	4- 6 M
Final inspecting	) 1 F	1- 3 F	2- 6 F	4-12 F	) 1 F	1- 3 F	2- 6 F	4-12 F
Packaging, crating and warehousing 2/	) 1 M	(2 F	3- 4 F	4- 6 F	) 1 M	(2 F	3- 4 F	4- 6 F
		(2 M	2- 3 M	3- 5 M		(2 M	2- 3 M	3- 5 M
Other:								
Foreman	1	1	1	1	1	1	1	1
Forewoman	-	-	1	1	-	-	1	1
Helpers, cleanup, maintenance, etc.	1 M	2- 4 M	4- 6 M	8-12 M	1 M	2- 4 M	4- 6 M	8-12 M
Total per shift:								
Men	5	11-13	14-21	23-37	5	11-13	14-21	23-37
Women	4	14-21	26-39	50-76	4-5	17-26	31-49	60-96
Foreman	1	1	1	1	1	1	1	1
Forewoman	-	-	1	1	-	-	1	1
Indirect Labor								
Bookkeeper	)		1- 2	2- 3	)		1- 2	2- 3
Stenographers	) 1	2- 3	1	1- 2	) 1	2- 3	1	1- 2
Payroll and other clerks	)		1- 2	2- 4	)		1- 2	2- 4
Superintendent		1	1	1		1	1	1
Field man	1		1	1	1		1	1
Plant chemist (and assistants)		1	1	1- 2		1	1	1- 2
Total, one shift per day	2	4- 5	6- 8	8-13	2	4- 5	6- 8	8-13

1/ Capacity given in tons per 24 hours, unprepared basis.

2/ Labor requirements for packaging depend on type of container used. Labor figures shown here are based upon the use of five-gallon cans, automatic sealing machines, and prefabricated cartons, boxes, or crates. The use of metal foil containers or other types of packages will involve a different labor set-up.

The type of drier affects labor requirements. A 50-ton tunnel drier requires from 10 to 15 employees per shift for loading and stacking trays, moving cars, operating the drier, scraping trays, and washing trays. If a conveyor-type drier is used instead, and a suitable mechanical arrangement is available for spreading the product evenly over the conveyor belt, from 2 to 4 employees per shift may be necessary to handle the drying operations in a plant of the same size.

An estimate of probable labor costs is presented in Table 7. Careful analysis shows that the small plants are at a decided competitive disadvantage when compared with the larger ones.

Estimated Construction Costs

Estimates of building and equipment costs are shown in tables 8 and 9. These costs must be considered as rough approximations since they cannot possibly include all items. Even a plant that has been completely engineered before construction may present the owner with additional cost items before it is finished. Conditions vary throughout the country, and these variations materially affect any attempt to arrive at generalizations regarding costs.

Low and high estimates of cost are given. There is only a remote likelihood that any plant will or should be constructed at a minimum of cost for all items. Unless constructed under unusual circumstances, such a plant would probably experience operating difficulties due to lack of equipment and limited floor space. Dehydration plants should be balanced units, and the costs of various parts will be low or high in accordance with the circumstances affecting each particular machine, operation, or floor space requirement.

Estimated Processing Costs

Table 10 presents a partial summary of estimated processing costs for dehydrating these four vegetables. The cost elements included are raw material, direct and indirect labor, packaging, and utilities.

Other indirect and overhead costs have not been included in this calculation. Some operators believe that total overhead costs should not average more than 50 percent of direct labor, while others say that these costs may be equal to or even greater than the cost of direct labor. Still others believe that overhead costs have no relation to labor and cannot be accurately estimated on a labor basis. Wide variations occur from plant to plant due to the fact that overhead costs in vegetable dehydration depend on such factors as the length of operating season, cost of buildings and equipment, local conditions, and managerial policies. The complexity of these interrelated factors is such that no general estimates of overhead cost have been attempted.

The cost figures, although not complete, are useful guides within the indicated limits. A prospective operator can combine these figures with data specifically relating to his proposed operation and thus more accurately estimate what his costs are likely to be.

TABLE 7.--Estimated labor cost per dry pound[1/]

	Carrots				Potatoes			
	5-ton plant[2/]	25-ton plant[2/]	50-ton plant[2/]	100-ton plant[2/]	5-ton plant[2/]	25-ton plant[2/]	50-ton plant[2/]	100-ton plant[2/]
Av. hourly output per 24-hr. day, dry basis	38 lbs.	190 lbs.	380 lbs.	760 lbs.	60 lbs	300 lbs.	600 lbs.	1,200 lbs.
Direct labor cost per hour								
Men - 75¢ per hr.	$3.75	$ 8.25-9.75	$10.50-15.75	$17.25-27.75	$ 3.75	$ 8.25- 9.75	$10.50-15.75	$17.25-27.75
Women - 60¢ per hr.	2.40	8.40-12.60	15.60-23.40	30.00-45.60	3.00-3.60	12.00-21.00	22.80-39.60	44.40-78.00
Foremen	1.00	1.25	1.25	1.50	1.00	1.25	1.25	1.50
Forewomen	-	-	.85	1.00	-	-	.85	1.00
Total	$7.15	$17.90-23.60	$28.20-41.25	$49.75-75.85	$7.75-8.35	$21.50-32.00	$35.40-57.45	$64.15-108.25
Indirect labor, cost per hour								
Bookkeepers-75¢/hr.	)		.75-1.50	1.50-2.25	)		.75-1.50	1.50-2.25
Stenographers-65¢/hr.	) .75	1.40-2.15	.65	.65-1.30	) .75	1.40-2.15	.65	.65-1.30
Payroll and other	)				)			
clerks - 75¢/hr.	)		.75-1.50	1.50-3.00	)		.75-1.50	1.50-3.00
Superintendent	)	1.50	1.50	1.75	)	1.50	1.50	1.75
Field man	)1.25		1.25	1.50	) 1.25		1.25	1.50
Plant chemist (and assistants)	)	1.00	1.25	1.25-2.50	)	1.00	1.25	1.25-2.50
Total	$2.00	$ 3.90-4.65	$ 6.15- 7.65	$ 8.15-12.30	$ 2.00	$3.90-4.65	$ 6.15-7.65	$8.15-12.30
1/3 applicable to each of 3 shifts	.70	1.30-1.55	2.05- 2.55	2.75- 4.10	.70	1.30-1.55	2.05-2.55	2.70- 4.10
Total labor cost per hour	$7.85	$19.20-25.15	$30.25-43.80	$52.50-79.95	$8.45-9.05	$22.80-33.55	$37.45-60.00	$66.85-112.35
Labor cost per dry lb.	20.5¢	10.0-13.0¢	8.0-11.5¢	7.0-10.5¢	14.0-15.0¢	7.5-11.0¢	6.0-10.0¢	5.5-9.5¢

1/ Assumed overall shrinkage ratios are: 11 to 1 for carrots; 7 to 1 for potatoes.

TABLE 7.--Continued

	Rutabagas				Sweetpotatoes			
	5-ton plant2/	25-ton plant2/	50-ton plant2/	100-ton plant2/	5-ton plant2/	25-ton plant2/	50-ton plant2/	100-ton plant2/
Av. hourly output per 24-hr. day, dry basis	40 lbs.	200 lbs.	395 lbs.	790 lbs.	85 lbs.	415 lbs.	830 lbs.	1,670 lbs.
Direct labor cost per hour								
Men - 75¢ per hr.	$3.75	$ 8.25- 9.75	$10.50-15.75	$17.25-27.75	$ 3.75	$ 8.25- 9.75	$10.50-15.75	$17.25-27.75
Women - 60¢ per hr.	2.40	8.40-12.60	15.00-23.40	30.00-45.60	2.40-3.00	10.20-15.60	18.60-29.40	36.00-57.60
Foreman	1.00	1.25	1.25	1.50	1.00	1.25	1.25	1.50
Forewoman	-	-	.85	1.00	-	-	.85	1.00
Total	$7.15	$17.90-23.60	$27.60-41.25	$49.75-75.85	$7.15-7.75	$19.70-26.60	$31.20-47.25	$55.75-87.85
Indirect labor cost per hour								
Bookkeepers-75¢/hr.)			.75- 1.50	1.50- 2.25)			.75- 1.50	1.50- 2.25
Stenographers-65¢/hr.)	.75	1.40- 2.15	.65	.65- 1.30)	.75	1.40- 2.15	.65	.65- 1.30
Payroll and other)				)				
clerks - 75¢/hr.)			.75- 1.50	1.50- 3.00)			.75- 1.50	1.50- 3.00
Superintendent)		1.50	1.50	1.75)		1.50	1.50	1.75
Field man)	1.25		1.25	1.50)	1.25		1.25	1.50
Plant chemist (and)				)				
assistants))		1.00	1.25	1.25- 2.50)		1.00	1.25	1.25- 2.50
Total	$2.00	$ 3.90- 4.65	$ 6.15- 7.65	$ 8.15-12.30	$2.00	$ 3.90- 4.65	$ 6.15-7.65	$ 8.15-12.30
1/3 applicable to each of 3 shifts	.70	1.30- 1.55	2.05- 2.55	2.75- 4.10	.70	1.30- 1.55	2.05- 2.55	2.75- 4.10
Total labor cost per hour	$7.85	$19.20-25.15	$29.65-43.80	$52.50-79.95	$7.85-8.45	$21.00-28.15	$33.25-49.80	$58.50-91.95
Labor cost per dry pound	19.5¢	9.5-12.5¢	7.5-11.0¢	6.5-10.0¢	9.0-10.0¢	5.0-7.0¢	4.0-6.0¢	3.5-5.5¢

1/ Assumed overall shrinkage ratios are: $10\frac{1}{2}$ to 1 for rutabagas; 5 to 1 for sweetpotatoes.

2/ Capacity given in tons per 24 hours, unprepared basis.

TABLE 8.—Estimated cost of preparation, final inspection and packaging equipment

	5-ton plant 1/		25-ton plant 1/		50-ton plant 1/		100-ton plant 1/	
	Low	High	Low	High	Low	High	Low	High
Preparation equipment								
Hand trucks	$ 15	$ 25	$ 50	$ 100	$ 100	$ 150	$ 100	$ 200
Conveyors			500	800	800	1,000	1,000	1,500
Elevators			500	700	600	800	800	1,000
Washer	300	600	600	800	1,000	1,200	1,100	1,400
Peelers	300	500						
Peeling scalders			1,000	1,500	1,500	2,000	2,500	3,000
High pressure washers and pumps			1,000	2,000	1,500	2,500	2,500	3,000
Trimming belts or tables	75	100	1,500	3,000	2,000	4,000	4,000	8,000
Conveyors and elevators			600	1,000	800	1,200	1,500	2,000
Cutters	500	700	800	1,300	800	1,300	1,500	2,500
Blanchers	1,000	1,200	2,000	3,000	3,000	5,000	6,000	10,000
Total	2,190	3,125	8,550	14,200	12,100	19,150	21,000	32,600
Final inspection and packaging equipment								
Hoppers and shaker sieves	50	100	300	500	400	600	400	600
Inspection belts			400	600	600	1,000	1,000	1,400
Hoppers, scales and packaging equipment	100	150	300	600	400	800	500	1,000
Roller conveyor			200	400	250	500	400	600
Hand trucks and tools	50	100	100	200	150	300	250	400
Total	200	350	1,300	2,300	1,800	3,200	2,550	4,000
Total cost of equipment	2,390	3,475	9,850	16,500	13,900	22,350	23,550	36,600
Approximate installation costs (25% of equipment)	600	850	2,450	4,100	3,500	5,600	5,900	9,150
Total cost installed	$2,990	$4,325	$12,300	$20,600	$17,400	$27,950	$29,450	$45,750

1/ Capacity given in tons per 24 hours, unprepared basis.

TABLE 9.—Approximate building and equipment costs exclusive of boiler equipment[1]

Carrots, Potatoes and Rutabagas[2]

Item of Plant	5-ton plant[3] Low	5-ton plant[3] High	25-ton plant[3] Low	25-ton plant[3] High	50-ton plant[3] Low	50-ton plant[3] High	100-ton plant[3] Low	100-ton plant[3] High
Preparation, final inspection, and packaging equipment	$3,000	$ 4,300	$12,000	$21,000	$17,000	$28,000	$ 29,000	$ 46,000
Drying equipment	4,000	6,000	12,000	15,000	25,000	30,000	50,000	60,000
Building space at $1 per sq. ft.	2,600	5,000	11,000	18,000	20,000	32,000	33,000	57,000
Sewerage	—	—	1,000	2,000	2,000	3,000	3,000	4,000
Office and laboratory equipment	100	500	500	1,000	500	2,000	1,000	3,000
Machine shop, tools, and equipment	100	200	250	500	500	1,000	500	1,500
Total cost, exclusive of boiler equipment[1]	$9,800	$16,000	$36,750	$57,500	$65,000	$96,000	$116,500	$171,500
Cost per ton of daily capacity (unprepared basis)	$2,000	$ 3,200	$ 1,500	$ 2,300	$ 1,300	$ 1,900	$ 1,200	$ 1,700

1/ No cost allowances are included for boilers because many dehydration plants are installing secondhand boilers at a fraction of cost of new ones. For example, one plant purchased a secondhand 125 h.p. boiler at an installed cost, including accessory equipment, of approximately $8,000. Estimates of costs of new boilers including piping and auxiliaries, but not foundations or buildings, are as follows: From 1 to 2 boiler h.p. are required for each ton of daily capacity, unprepared basis, for blanching and incidental uses only.

Developed H.P.	Price per H.P.	Developed H.P.	Price per H.P.
25	$250	200	$125
50	200	300	100
100	170	500	70

2/ Due to their drying characteristics, sweetpotatoes are not included. The drier and the floor space requirements are different because of the need for more tray area.

3/ Capacity given in tons per 24 hours, unprepared basis.

TABLE 10.--Estimated costs of production exclusive of overhead costs and profits -- cents per dry pound

	Carrots 1/				Potatoes 1/			
	5-ton plant 2/	25-ton plant 2/	50-ton plant 2/	100-ton plant 2/	5-ton plant 2/	25-ton plant 2/	50-ton plant 2/	100-ton plant 2/
	Cents per dry pound							
Processing costs per dry pound								
Labor, direct and indirect 3/ (From Table 7)	20.5	10.0-13.0	8.0-11.5	7.0-10.5	14.0-15.0	7.5-11.0	6.0-10.0	5.5- 9.5
Containers 4/	2.5	2.5	2.5	2.5	4.0	4.0	4.0	4.0
Utilities	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Total	24-25	13.5-17.5	11.5-16.0	10.5-15.0	19.0-21.0	12.5-17.0	11.0-16.0	10.5-15.5
Raw material costs per dry pound								
Cost at $20 per ton	11.0	11.0	11.0	11.0	7.0	7.0	7.0	7.0
" " 25 " "	14.0	14.0	14.0	14.0	9.0	9.0	9.0	9.0
" " 30 " "	16.5	16.5	16.5	16.5	10.5	10.5	10.5	10.5
" " 35 " "	19.5	19.5	19.5	19.5	12.5	12.5	12.5	12.5
" " 40 " "	22.0	22.0	22.0	22.0	14.0	14.0	14.0	14.0
" " 45 " "	25.0	25.0	25.0	25.0	16.0	16.0	16.0	16.0
Total costs per dry pound not including overhead costs or profit								
Raw material at $20/ton	35.0-36.0	24.5-28.5	22.5-27.0	21.5-26.0	26.0-28.0	19.5-24.0	18.0-23.0	17.5-22.5
" " " 25/ton	38.0-39.0	27.5-31.5	25.5-30.0	24.5-29.0	28.0-30.0	21.5-26.0	20.0-25.0	19.5-24.5
" " " 30/ton	40.5-41.5	30.0-34.0	28.0-32.5	27.0-31.5	29.5-31.5	23.0-27.5	21.5-26.5	21.0-26.0
" " " 35/ton	43.5-44.5	33.0-37.0	31.0-35.5	30.0-34.5	31.5-33.5	25.0-29.5	23.5-28.5	23.0-28.0
" " " 40/ton	46.0-47.0	35.5-39.5	33.5-38.0	32.5-37.0	33.0-35.0	26.5-31.0	25.0-30.0	24.5-29.5
" " " 45/ton	49.0-50.0	38.5-42.5	36.5-41.0	35.5-40.0	35.0-37.0	28.5-33.0	27.0-32.0	26.5-31.5

1/ Assumed overall shrinkage ratios are: 11 to 1 for carrots; 7 to 1 for potatoes.

TABLE 10.--Continued

	Rutabagas 1/				Sweetpotatoes 1/			
	5-ton plant 2/	25-ton plant 2/	50-ton plant 2/	100-ton plant 2/	5-ton plant 2/	25-ton plant 2/	50-ton plant 2/	100-ton plant 2/
	Cents per dry pound							
Processing costs per dry pound								
Labor, direct and indirect 3/ (From Table 7)	19.5	9.5-12.5	7.5-11.0	6.5-10.0	9.0-10.0	5.0- 7.0	4.0- 6.0	3.5- 5.5
Containers 4/	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Utilities	1-2	1-2	1-2	1-2	1-2	1-2	1-2	1-2
Total	24.0-25.0	14.0-18.0	12.0-16.5	10.5-15.5	13.5-15.5	9.5-12.5	8.5-11.5	8.0-11.0
Raw material costs per dry pound								
Cost at $20 per ton	10.5	10.5	10.5	10.5	5.0	5.0	5.0	5.0
" " 25 " "	13.0	13.0	13.0	13.0	6.5	6.5	6.5	6.5
" " 30 " "	16.0	16.0	16.0	16.0	7.5	7.5	7.5	7.5
" " 35 " "	18.5	18.5	18.5	18.5	9.0	9.0	9.0	9.0
" " 40 " "	21.0	21.0	21.0	21.0	10.0	10.0	10.0	10.0
" " 45 " "	23.5	23.5	23.5	23.5	11.5	11.5	11.5	11.5
Total costs per dry pound not including overhead costs or profit								
Raw material at $20/ton	34.5-35.5	24.5-28.5	22.5-27.0	21.0-26.0	18.5-20.5	14.5-17.5	13.5-16.5	13.0-16.0
" " " 25/ton	37.0-38.0	27.0-31.0	25.0-29.5	23.5-28.5	20.0-22.0	16.0-19.0	15.0-18.0	14.5-17.5
" " " 30/ton	40.0-41.0	30.0-34.0	28.0-32.5	26.5-31.5	21.0-23.0	17.0-20.0	16.0-19.0	15.5-18.5
" " " 35/ton	42.5-43.5	32.5-36.5	30.5-35.0	29.0-34.0	22.5-24.5	18.5-21.5	17.5-20.5	17.0-20.0
" " " 40/ton	45.0-46.0	35.0-39.0	33.0-37.5	31.5-36.5	23.5-25.5	19.5-22.5	18.5-21.5	18.0-21.0
" " " 45/ton	47.5-48.5	37.5-41.5	35.5-40.0	34.0-39.0	25.0-27.0	21.0-24.0	20.0-23.0	19.5-22.5

1/ Assumed overall shrinkage ratios are: 10½ to 1 for rutabagas; 5 to 1 for sweetpotatoes.
2/ Capacity given in tons per 24 hours, unprepared basis.
3/ The low limit of labor cost is a summation of the low estimates for each individual operation, as shown in Table 6; it is very unlikely that any plant will operate with an absolute minimum of labor in all operations.
4/ The cost of containers includes 25 cents for a single 5-gallon can and 30 cents for the wire bound wood box holding two cans; the total per can is 40 cents. Costs for other containers should be adjusted accordingly.

The figures are based upon continuous operation, a phenomenon rarely experienced in commercial plants. Where operations are interrupted or are discontinuous, suitable corrections must be applied. It is apparent, also, that the cost estimates must be adjusted in any particular situation according to labor rates, shrinkage ratios, and operating procedures.

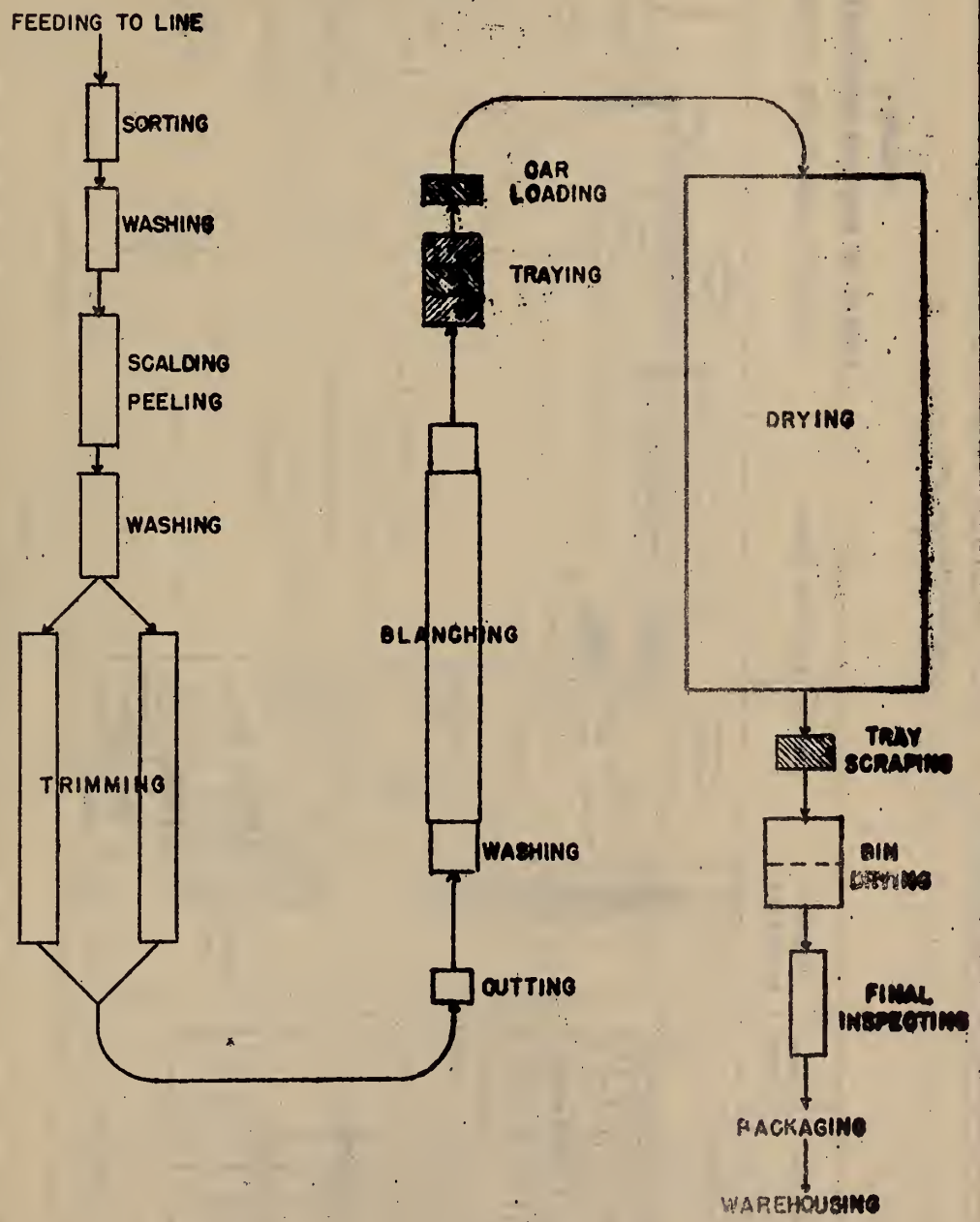
DEHYDRATION FLOW SHEET

FIGURE 1

FOR

POTATOES, CARROTS, SWEETPOTATOES, AND RUTABAGAS

(NOT SCALED)



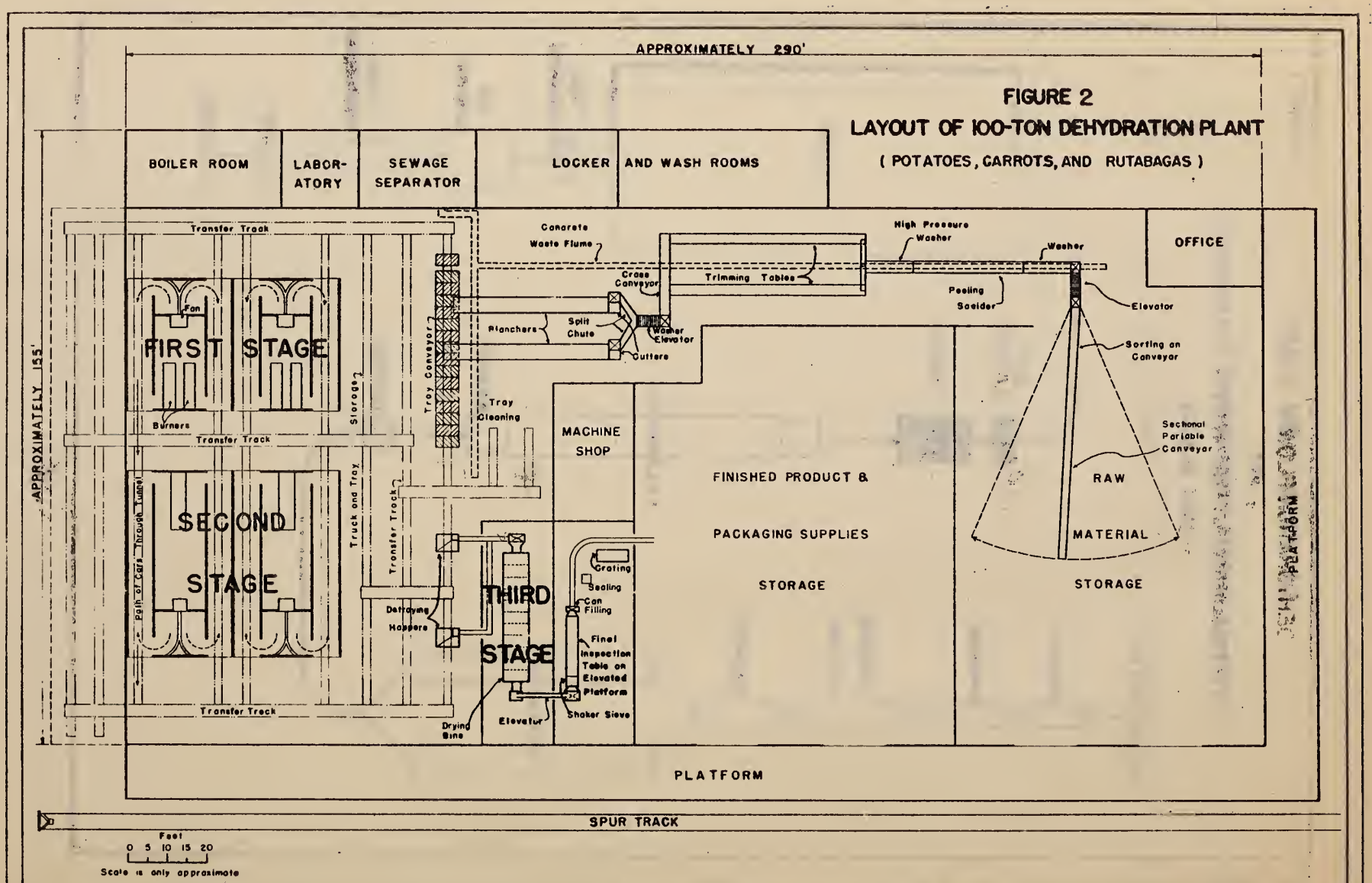


FIGURE 2

LAYOUT OF 100-TON DEHYDRATION PLANT

(POTATOES, CARROTS, AND RUTABAGAS)

FIGURE 3
LAYOUT OF 50-TON DEHYDRATION PLANT
(POTATOES, CARROTS, AND RUTABAGAS)

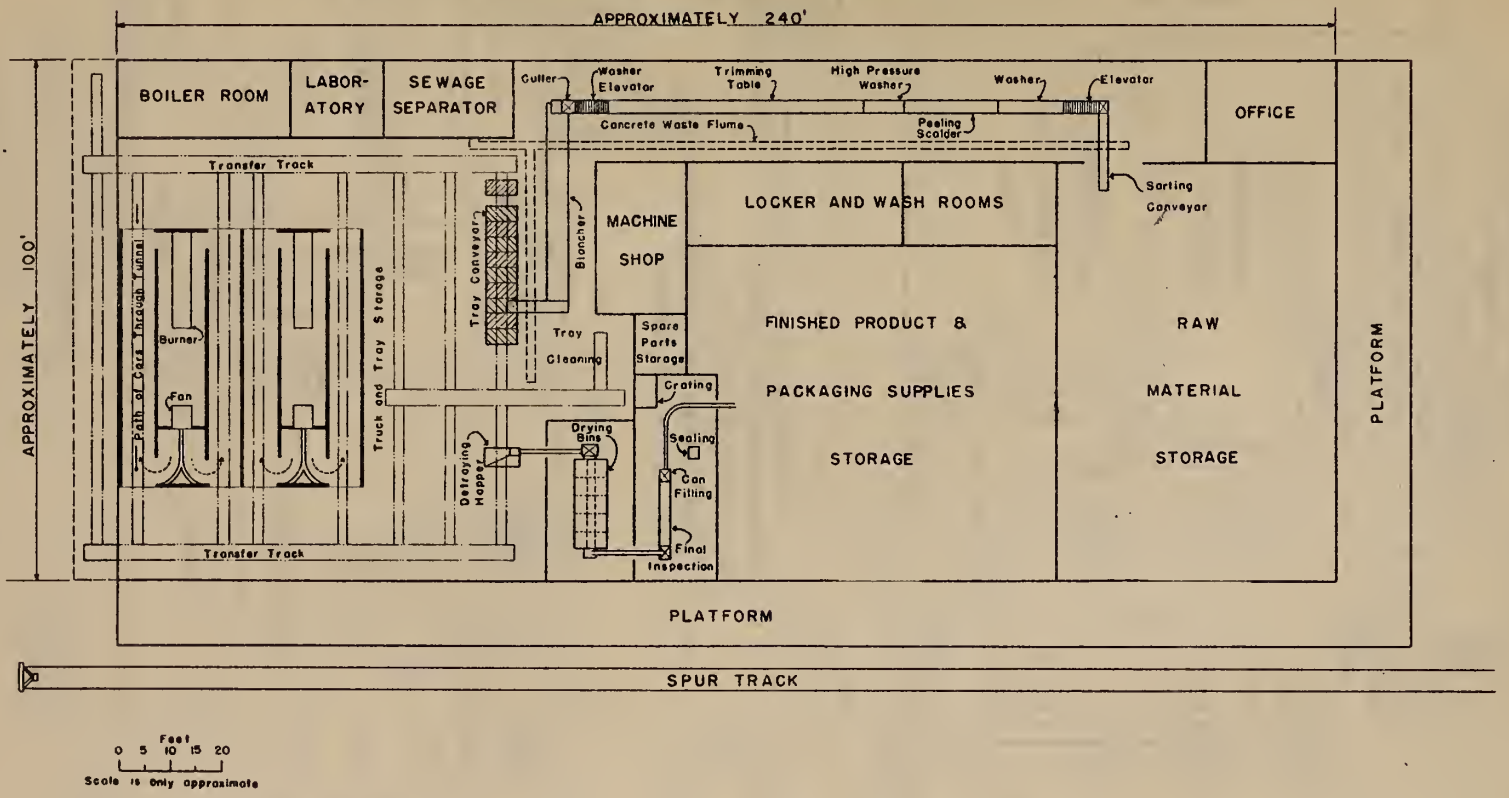


FIGURE 4

LAYOUT OF 25-TON DEHYDRATION PLANT-TUNNEL TYPE

(POTATOES , CARROTS, AND RUTABAGAS)

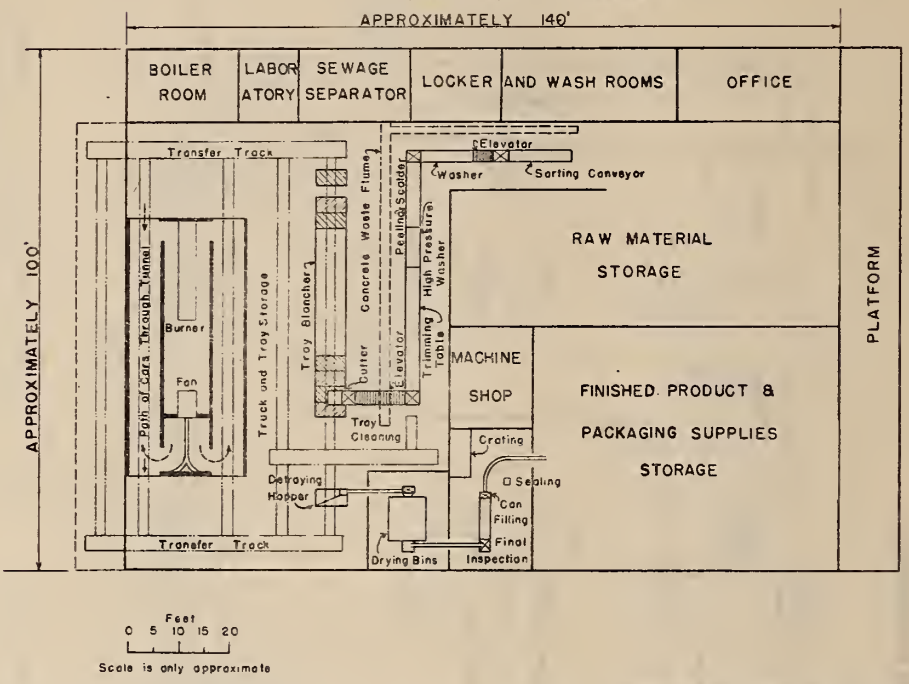
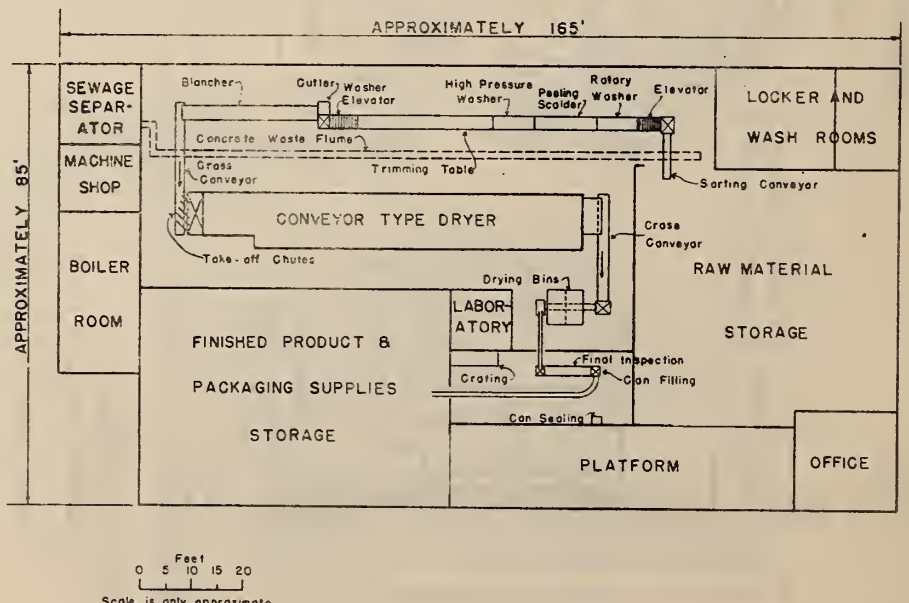


FIGURE 5

LAYOUT OF 25-TON DEHYDRATION PLANT-CONVEYOR TYPE

(POTATOES, CARROTS, AND RUTABAGAS)



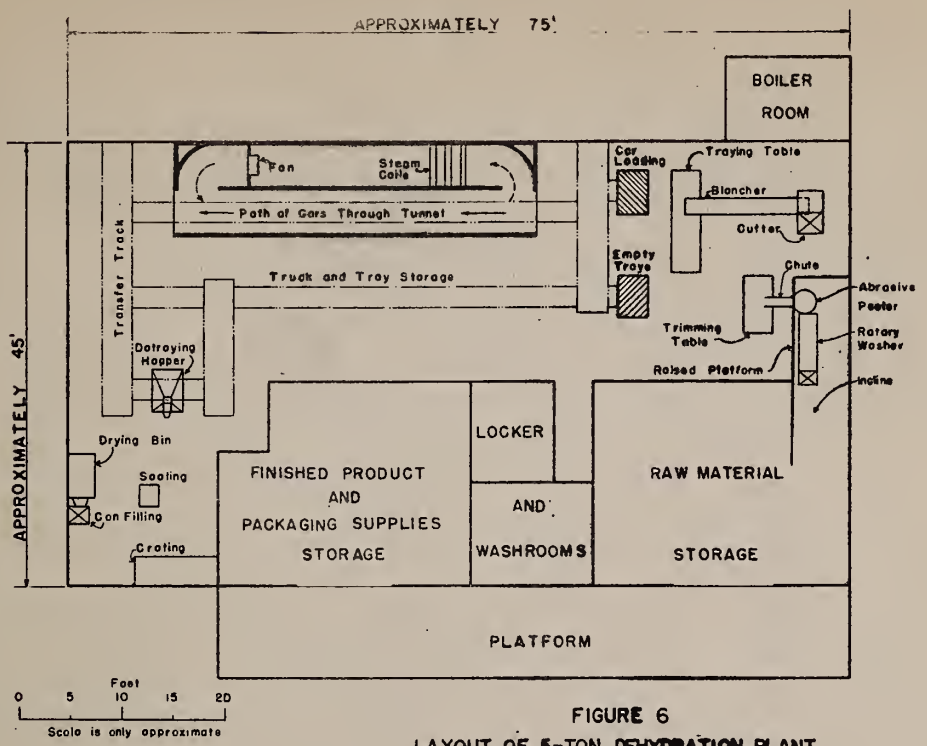
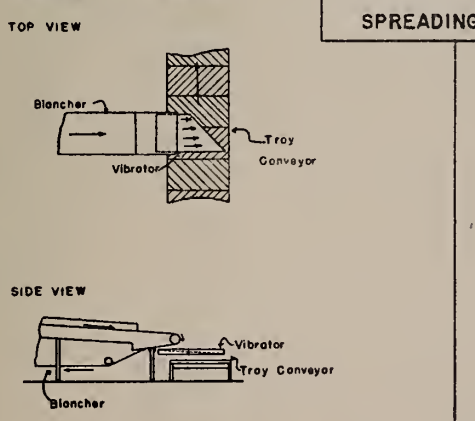
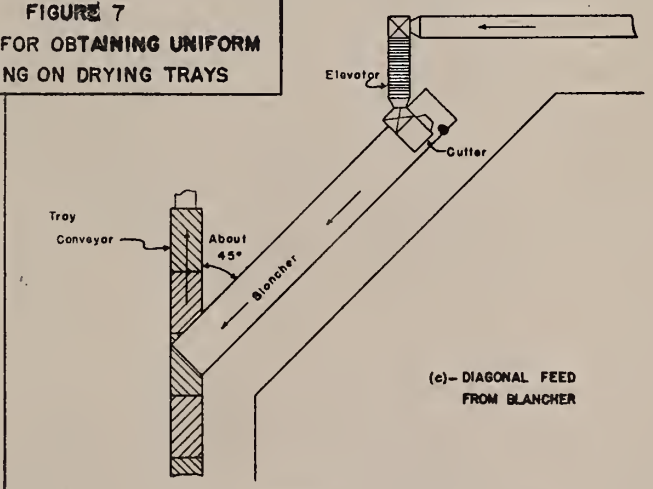
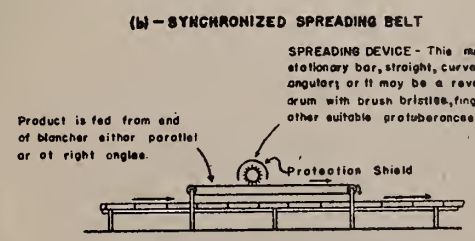


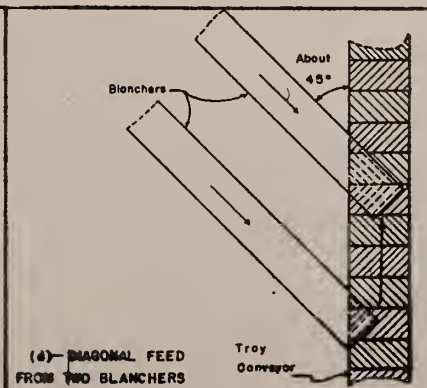
FIGURE 6
LAYOUT OF 5-TON DEHYDRATION PLANT
(POTATOES, CARROTS, AND RUTABAGAS)

FIGURE 7
METHODS FOR OBTAINING UNIFORM SPREADING ON DRYING TRAYS









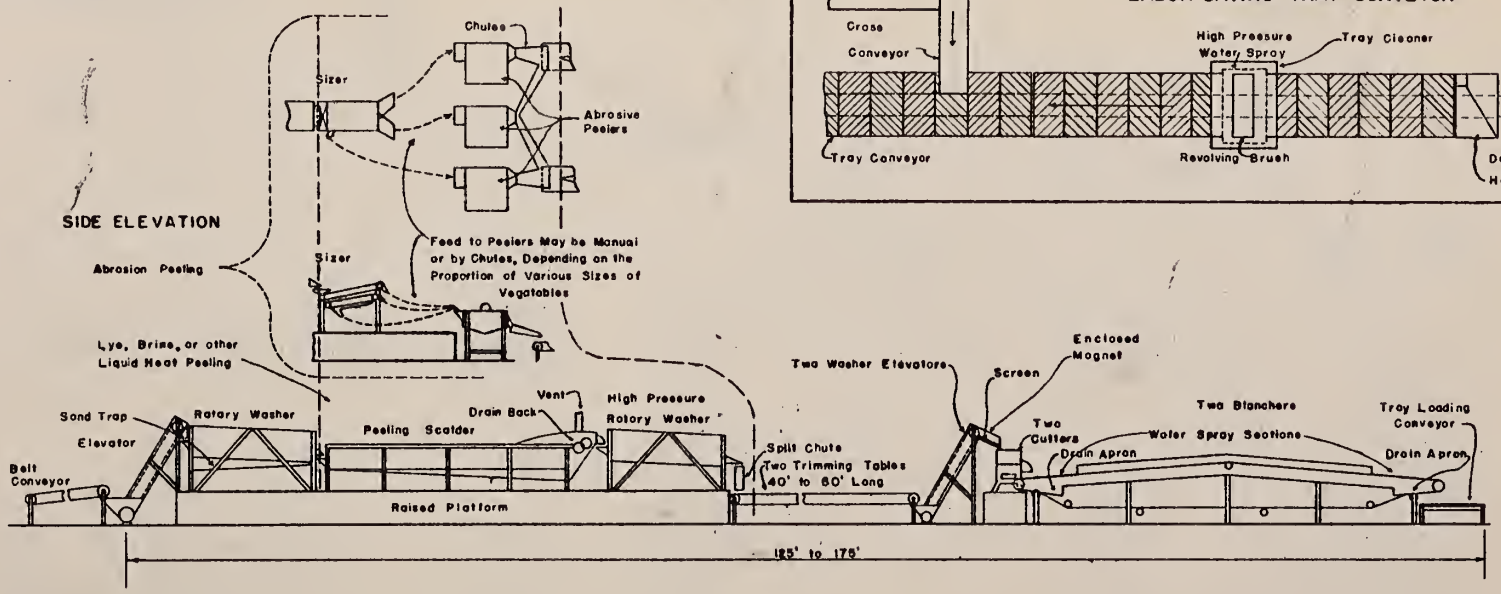


FIGURE 9

LABOR SAVING TRAY CONVEYOR

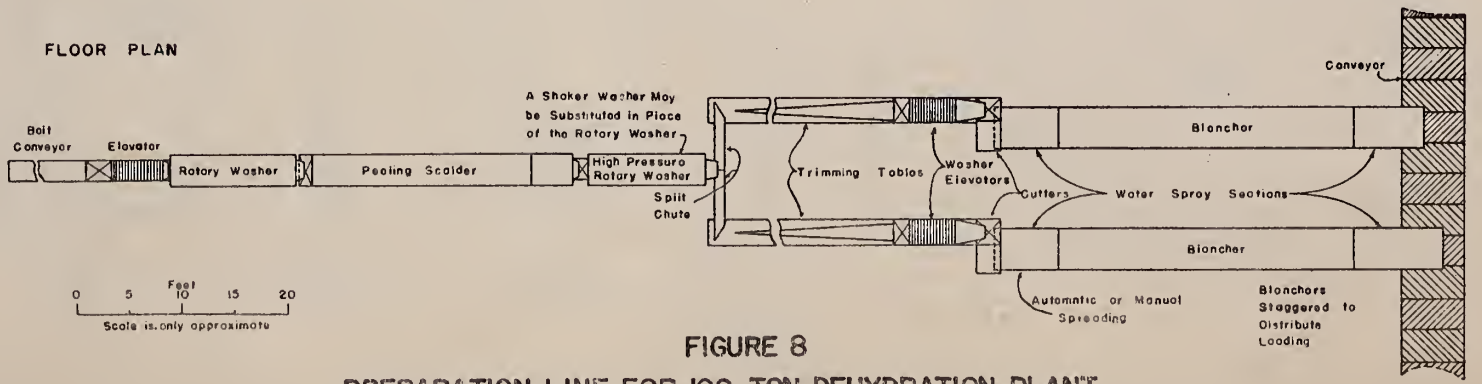


FIGURE 8

PREPARATION LINE FOR 100-TON DEHYDRATION PLANT

(POTATOES, CARROTS, SWEETPOTATOES, AND RUTABAGAS)